Jackson Labs

LC-XO-PLUS Kit User Manual

Document: 80200519
Version: 1.0
Date: 4 April, 2014

LC-XO-PLUS Board User Manual

Copyright © 2013, 2014 Jackson Labs Technologies, Inc.

1 Introduction . . . 1
1.1 Overview . . . 1
1.2 General Safety Precautions . . . 1
1.2.1 Grounding . . . 1
1.2.2 Power Connections . . . 2
1.2.3 Environmental Conditions . . . 2

2 Quick-Start Instructions . . . 3
2.1 Powering Up the Unit . . . 3
2.1.1 Supplied Accessories . . . 4
2.1.2 USB Serial Port . . . 5
2.1.3 Major connections . . . 5
2.2 Connecting the GPS Antenna . . . 7
2.3 Remote USB serial control . . . 7
2.3.1 “Help” and command overview . . . 8
2.3.2 Loop parameter adjustment . . . 8

3 Control and Command Utilities . . . 11
3.1 Description . . . 11
3.2 Z38XX Utility . . . 11
3.2.1 Installation and Set Up . . . 11
3.2.1.1 Parameter Setup . . . 12
3.2.1.2 Serial Echo . . . 12
3.2.1.3 Windows Compatibility . . . 13
3.2.2 Running the program . . . 14
3.2.2.1 Zoom and Pan . . . 14
3.2.3 View menu . . . 14
3.2.3.1 Satellite Azimuth/Elevation Chart . . . 15
3.2.3.2 Satellite C/N level Chart . . . 15
3.2.3.3 Holdover Uncertainty & Sats . . . 16
3.2.3.4 Time Stability Measures . . . 16
3.3 GPScon Utility . . . 18
3.3.1 Installation and Set Up . . . 18
3.3.1.1 Setting the options . . . 18
3.3.1.2 Communication Parameters . . . 18
3.3.1.3 Auxiliary parameters . . . 19
3.3.1.4 Other options . . . 21
3.3.2 Sending manual commands to the receiver . . . 21
3.3.3 Use of the mouse in graph mode . . . 22
3.3.4 Exporting the graphics . . . 24
3.4 Interpreting the Data . . . 25
3.5 Performance . . . 26

4 SCPI-Control Quick Start Instructions . . . 29
4.1 Introduction . . . 29
4.2 General SCPI Commands . . . 29
4.2.1 *IDN? . . . 29
4.2.2 HELP? . . . 29
4.3 GPS Subsystem . . . 30

© 2014 Jackson Labs Technologies, Inc.

4.3.1 GPS:SATellite . . . 30
4.3.2 GPS:SATellite:TRAcking:COUNt? . . . 30
4.3.3 GPS:SATellite:VISible:COUNt? . . . 30
4.3.4 NMEA Support . . . 30
4.3.5 GPS:GPGGA. . . . 31
4.3.6 GPS:GGASTat . . . 31
4.3.7 GPS:GPRMC . . . 31
4.3.8 GPS:XYZSPeed . . . 32
4.3.9 GPS:POSition? . . . 32
4.3.10 GPS:RESET ONCE . . . 32
4.3.11 GPS?. . . . 32
4.4 PTIME Subsystem . . . 32
4.4.1 PTIMe:TZONe? . . . 32
4.4.2 PTIMe:DATE? . . . 33
4.4.3 PTIMe:TIME? . . . 33
4.4.4 PTIMe:TIME:STRing? . . . 33
4.4.5 PTIMe:TINTerval? . . . 33
4.4.6 PTIME? . . . 33
4.5 SYNChronization Subsystem . . . 33
4.5.1 SYNChronization:SOURce:MODE [GPS|EXTernal|AUTO] . . . 34
4.5.2 SYNChronization:HOLDover:DURation? . . . 34
4.5.3 SYNChronization:HOLDover:INITiate . . . 34
4.5.4 SYNChronization:HOLDover:RECovery:INITiate . . . 34
4.5.5 SYNChronization:TINTerval? . . . 34
4.5.6 SYNChronization:IMMEdiate. . . . 34
4.5.7 SYNChronization:FEEstimate? . . . 35
4.5.8 SYNChronization:LOCKed? . . . 35
4.5.9 SYNChronization:health? . . . 35
4.5.10 SYNChronization?. . . . 36
4.6 DIAGnostic Subsystem . . . 36
4.6.1 DIAGnostic:ROSCillator:EFControl:RELative? . . . 36
4.6.2 DIAGnostic:ROSCillator:EFControl:ABSolute? . . . 36
4.7 MEASURE Subsystem . . . 36
4.7.1 MEASure:VOLTage?. . . . 37
4.7.2 MEASure:CURRent?. . . . 37
4.7.3 MEASure? . . . 37
4.8 SYSTEM Subsystem . . . 37
4.8.1 SYSTem:COMMunicate . . . 37
4.8.1.1 SYSTem:COMMunicate:SERial:ECHO . . . 37
4.8.1.2 SYSTem:COMMunicate:SERial:PROmpt . . . 37
4.8.1.3 SYSTem:COMMunicate:SERial:BAUD . . . 37
4.8.2 SYSTem:STATus? . . . 38
4.8.3 SYSTem:FACToryReset ONCE . . . 38
4.9 SERVO Subsystem. . . . 38
4.9.1 SERVo:COARSeDac . . . 38
4.9.2 SERVo:DACGain . . . 38
4.9.3 SERVo: EFCScale . . . 38
4.9.4 SERVo:EFCDamping . . . 39
4.9.5 SERVo:SLOPe . . . 39
4.9.6 SERVo:TEMPCOmpensation . . . 39
4.9.7 SERVo:AGINGcompensation . . . 39
4.9.8 SERVo:PHASECOrrection . . . 39

© 2014 Jackson Labs Technologies, Inc.

4.9.9 SERVo:1PPSoffset 39
4.9.10 SERVo:TRACe 40
4.9.11 SERVo? 40

5 Certification and Warranty 43
5.1 Certification 43
5.1.1 Warranty 43
5.1.2 Limitation of Warranty 43
5.1.3 Exclusive Remedies 44

© 2014 Jackson Labs Technologies, Inc.

© 2014 Jackson Labs Technologies, Inc.

1 Introduction

1.1 Overview

The LC-XO-PLUS GPSDO 10MHz reference Kit includes a high-performance GPS receiver that can acquire and track up to 50 GPS signals down to a state of the art –160dBm, a 32bit processor that runs a Real Time OS, a low-noise 5V CMOS 10MHz and 3.3V CMOS 1PPS output, USB control interface, precision voltage references, and DACs. It generates a low-noise 10MHz signal with typically better than 1E-010 precision and accuracy (0.1ppb), better than 250fs jitter (20Hz to 2MHz) and a 1PPS signal with typically better than +/-25ns stability when locked to GPS.

The unit is built as an easy-to-use small enclosed box that operates and receives power by plugging into a PC USB port, and into the supplied GPS antenna. The unit also provides a TTL level status output, and it may be operated from an optional 5V power supply. The board is supplied with a USB cable and matching wall-wart power supply, two MMCX to BNC adaptor cables, a GPS antenna with 10m length, Z38xx control, plotting, and command Windows application, and a quick-start guide. The unit provides an industry-standard NMEA GPS interface that can be enabled via software command and provides Position/Velocity/Timing (PVT) information, and also provides a UTC-synchronized 1PPS signal on the USB serial port DCD# pin for NTP applications. The unit can optionally be operated from an external 5V DC power supply instead of the USB cable and both cables may be connected at the same time.

1.2 General Safety Precautions

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design manufacture, and intended use of the instrument. Jackson Labs Technologies, Inc. assumes no liability for the customer’s failure to comply with these requirements.

1.2.1 Grounding

To avoid damaging the sensitive electronic components in the LC-XO-PLUS GSPDO kit always make sure to discharge any built-up electrostatic charge to a good ground source, such as power supply ground. This should be done before handling the circuit board or anything connected to it, i.e. the GPS antenna.

© 2014 Jackson Labs Technologies, Inc.

1.2.2 Power Connections

Make sure to connect the DC power to the device following the polarity indicated in Section 2.1 . Do not reverse the power pins as this will cause serious damage to the circuit board.

1.2.3 Environmental Conditions

This instrument is intended for indoor use. It is designed to operate at a maximum relative non-condensing humidity of 95% and at altitudes of up to 4000 meters. Refer to the specifications tables for the ac mains voltage requirements and ambient operating temperature range.

© 2014 Jackson Labs Technologies, Inc.

2 Quick-Start Instructions

2.1 Powering Up the Unit

The unit is essentially a plug-and-play product that only requires a power source and a GPS antenna to be connected to start generating highly-accurate CMOS 10MHz and 1PPS signals that are phase and frequency aligned to UTC (USNO) and thus allow NIST-tracability. To use the unit, simply plug in the power supply and antenna, and wait about 10 minutes typically for the GREEN “OK” LED to light up to indicate that the unit is locked to UTC with better than +/-200ns phase accuracy, and a frequency accuracy of better than 1ppb has been achieved. The internal software will auto-configure and auto-calibrate the unit without any user-interaction and the longer the unit runs the more accurate it will become.

The unit is powered directly from the USB cable, and/or from an optional external 5V DC source on the +5V header. The USB cable and the external 5V DC source may be connected at the same time as they are diode-protected from one another. The current is typically less than 0.15A at 5V. Connect a clean +5V power supply to the +5V header block if the USB cable is not going to be used, or is plugged-in intermittently. See Figure 2.3 for the proper polarity of the optional external 5V DC power connection. Reversing the polarity on the power connector will not damage the unit as it is diode reverse-polarity protected.

When communicating to the unit through the USB cable, Windows Vista, Windows-7 and Linux will auto-recognize the unit as a USB serial COM adaptor, and automatically assign a serial port to the unit. Windows will automatically load the USB COM driver for the board, and may need to have access to the internet to download the latest driver from the Microsoft update website. The user can verify the COM port that windows assigned to the unit under the Computer Management window (right click on computer and press the “MANAGE” button under Windows-7, or go to Control Panel/Computer Management). The unit should show up as a standard serial port adaptor under the “Ports (COM& LPT)” Icon. Please note down this port number, as it is required for the initialization of application software.

The unit will start to search for Satellites as soon as power is applied, and will start to lock the internal TCXO to UTC as soon as GPS antenna is attached and more than 3 sats become visible. After 30 minutes or less the unit should stabilize the frequency, and all event indicators should be off resulting in the Green “OK” LED to be lit up. At this time the Green LED will indicate the unit is

© 2014 Jackson Labs Technologies, Inc.

fully synchronized to UTC, and generating a stable and accurate 10MHz output signal. The Green LED may go off momentarily from time to time as airflow touches the unit or Sats come in and out of view, this is normal behavior.

You may place the GPS antenna in a window, but it is recommended to place the GPS antenna with a full view of the sky for best performance. The antenna cable can be extended to 10m or more with high quality antenna cable (use quad shielded RG-6 75 Ohms cable, or high-quality 50 Ohms coax cable) without significant loss of signal quality.

WARNING: Make sure to use a proper and certified Antenna Lightning Arrestor when placing the antenna outside as lightning strikes can cause damage, injury, or death to equipment and personell.

Figure 2.1 LC-XO-Plus Desktop Enclosure

2.1.1 Supplied Accessories

The LC-XO-PLUS kit is supplied with a GPS antenna with 10m cable, a USB cable, a USB wall-wart, and two MMCX to BNC adaptor cables and is ready-to-go out of the box.

The unit must be used with straight-in MMCX connectors as right-angle MMCX connectors will generate excessive torque on the MMCX receptacles and will cause these to get damaged. Please ensure that only straight-in MMCX cables are used on the LC-XO-PLUS enclosure.

© 2014 Jackson Labs Technologies, Inc.

Figure 2.2 LC-XO-PLUS Kit

2.1.2 USB Serial Port

The LC-XO-PLUS unit has an internal RS-232 to USB serial port adaptor. This allows the unit to be directly connected to a PC's USB port, from which it will receive power and serial control, and no external RS-232 to USB adaptor is required. The term "RS-232" and USB serial port are used interchangeably, as the RS-232 port is implemented and connected via the USB serial connection. Windows and Linux has built-in support for this optional serial port functionality.

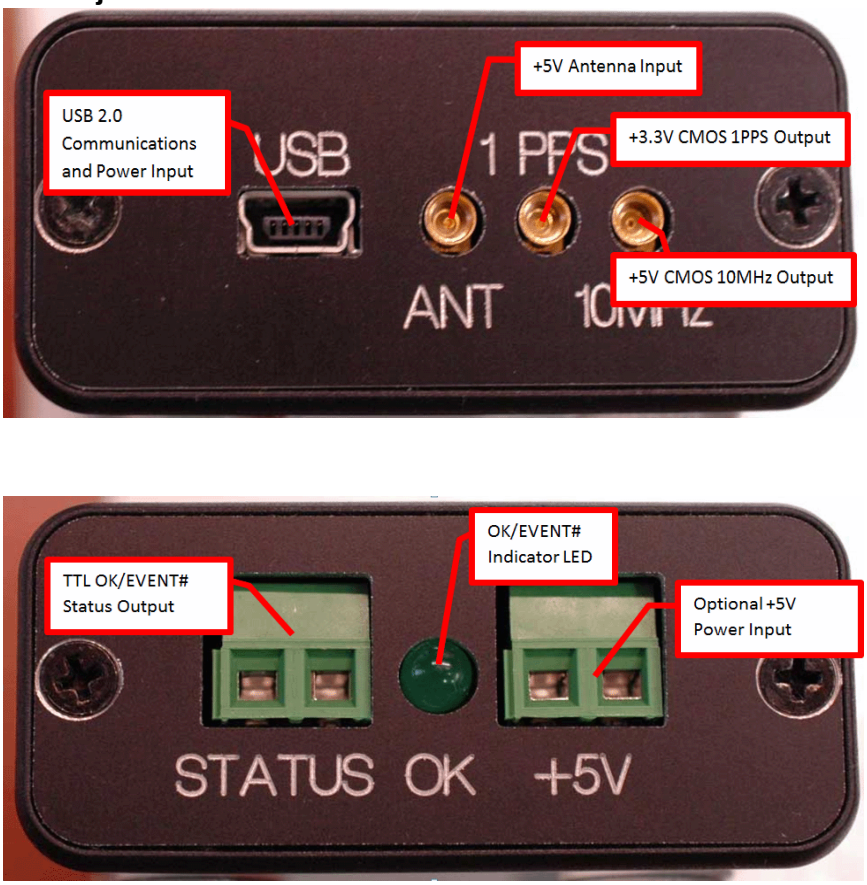
2.1.3 Major connections

The LC-XO-PLUS unit provides two green optional headers. The user will have to unscrew the back-plate and remove the unit from its enclosure to gain access to the lock screws of the green header blocks. Insert the wires into the headers, and lightly tighten the header block screws to secure the wires in the green header blocks, then close the enclosure by securing the two screws in the back-plate.

The major connections and features of the LC-XO-PLUS desktop enclosure are shown in :Figure 2.3.

© 2014 Jackson Labs Technologies, Inc.

Figure 2.3 Major connections to LC-XO-PLUS enclosure



© 2014 Jackson Labs Technologies, Inc.

Table 2.1 shows the LC-XO-PLUS enclosure hardware connectors

Table 2.1 LC-XO-PLUS enclosure hardware connectors

Ref	Name	Function	Specification	Pinning
Optional External Power	+5V	Optional External Clean +5V Supply. Use when USB power supply is not available	5V DC +/-10%, <0.15A, <10mVac	Left Pin: +5V, Right Pin: GND
Status	Status Header	Event and Lock Status Indicator	TTL +3.3V Status Output 3.3V == ALL IS WELL 0V == EVENT Ocurred	Left Pin: STATUS, Right Pin: GND
10MHz	10MHz CMOS Out	10MHz Output	+5V CMOS 10MHz Output	Center-10MHz Output, Shield-GND
1PPS	1PPS CMOS Out	1PPS Signal Aligned to UTC	+3.3V CMOS 1PPS Output	Center-1PPS Output, Shield-GND
USB	USB Port	Supplies Power and control	Standard USB 2.0 Full Speed	Mini USB

2.2 Connecting the GPS Antenna

Connect the GPS antenna to the MMCX connector shown in Figure 2.3. Please make sure to connect the GPS antenna prior to connecting the USB or power cable to the unit.

Caution: use a Lightning Arrestor on your Antenna setup.

The LC-XO-PLUS GPS receiver includes a 50 channel high-sensitivity GPS receiver with very fast lock time. It does not require any self-survey or position-hold mode (auto survey), and thus can be used in mobile platforms.

The LC-XO-PLUS GPSDO is capable of generating standard navigation messages (see GPS:GPGGA and GPS:GPRMC RS-232 commands) that are compatible with most GPS based navigation software. Please note that LC-XO-PLUS GPSDO indicates MSL height (rather than GPS height) in its GPGGA, *GPS?* and *syst:stat?* output strings.

The GPS receiver generates a 1PPS time signal that is phase synchronized to UTC. This 1PPS signal is used to frequency-lock the 10MHz Sine-Wave output of the LC-XO-PLUS GPSDO GPSDO to UTC, thus disciplining the unit's 10MHz frequency output to the US Naval master clock for very high frequency accuracy (typically better than 1ppb of frequency accuracy when locked to GPS). Over the long term, the LC-XO-PLUS GPSDO will out-perform free-running Cesium Atomic Frequency Standards.

2.3 Remote USB serial control

- The unit is controlled via the USB Serial port at 115200 baud, 8N1. Other Baud Rates can be set via SCPI commands over the serial port.
- Connect the PC via the USB cable and connector, attaching the LC-XO-PLUS unit to your PC's Hyperterminal, or the Z38xx software available on the included CD ROM, or the optional GPSCon software package. Please initialize your PC application software to the proper COM port

© 2014 Jackson Labs Technologies, Inc.

(automatically assigned by Windows) and configure the application software for 115200 Baud, 8 bits, no parity, 1 stop bit, and no flow control where applicable.

2.3.1 “Help” and command overview

- A listing of the available USB/RS-232 commands can be shown by typing "help?" when using TeraTerm (recommended) or Hyperterm.
- "*IDN?" can be used to see if the connection works. Both commands need to be followed by pressing “Enter”.

2.3.2 Loop parameter adjustment

- All loop parameters can be controlled via the RS-232 serial port.
- Loop parameters are optimized for the OCXO on the board, and changing the factory settings may result in the unit’s performance to deteriorate.

The commands to control the loop parameters are part of the servo? command. See also the **SERVO Subsystem** section in Chapter 3 (Section 4.9).

The individual commands are:

EFC Scale: this is the proportional gain of the PID loop. Higher values will give quicker convergence, and faster locking of the GPS time (lower loop time constant), lower values give less noise. Values between 0.7 and 6.0 are typical.

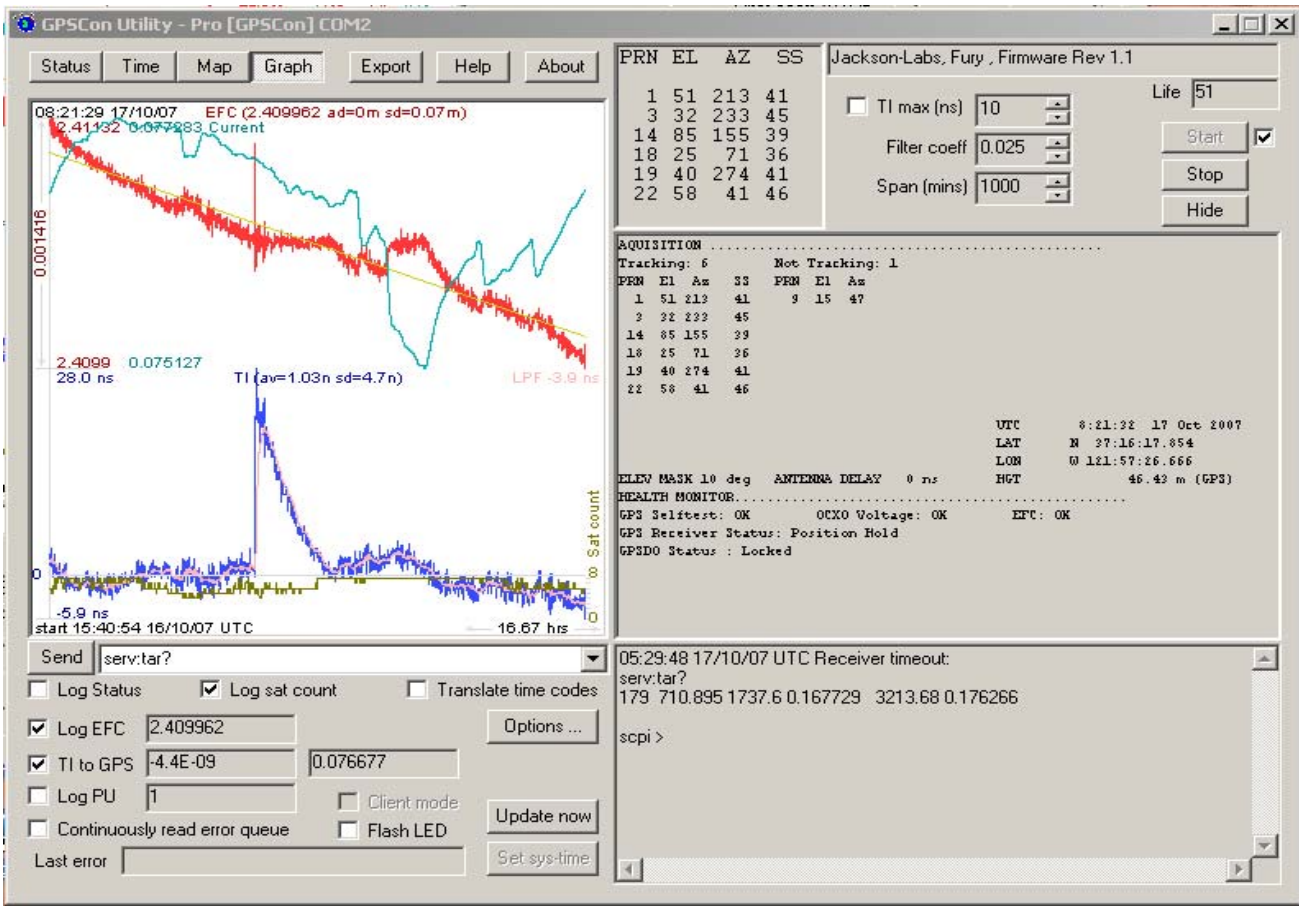
EFC Damping: overall IIR filter time constant. Higher values increase loop time constant. Jackson Labs Technologies, Inc. typically uses values between 10 to 50. Setting this value too high may cause loop instability.

Phase compensation: this is the Integral part of the PID loop. This corrects phase offsets between the LC-XO-PLUS GPSDO 1PPS signal and the UTC 1PPS signal as generated by the GPS receiver. Set higher values for tighter phase-following at the expense of frequency stability. Typical values range from 4 - 30, 25 being the default. Setting this value too high may cause loop instability.

A well-compensated unit will show performance similar to the plot in Figure 2.4 when experiencing small perturbations

© 2014 Jackson Labs Technologies, Inc.

Figure 2.4 LC-XO-PLUS GPSDO phase compensation plo



© 2014 Jackson Labs Technologies, Inc.

© 2014 Jackson Labs Technologies, Inc.

3 Control and Command Utilities

3.1 Description

The LC-XO-PLUS Kit comes with a CD including a freeware program to control and monitor the unit called Z38xx. This program runs under Windows, and the latest version is also available on the Jackson Labs Technologies, Inc. website (www.jackson-labs.com) under the Support tab.

Z38xx can be used to monitor and graphically plot the frequency and phase stability of the unit, the number of Satellites being tracked, and various other GPS and TCXO performance parameters. Z38xx needs to be properly configured under the “PARAMETERS” tab prior to operation by setting up the correct serial parameters (115.2KBaud, 8N1).

Please consult the Z38xx user manual included in the CD ROM for further details.

Alternatively to the Z38xx application, GPSCon is a third-party program for the monitoring and control of a variety of GPS time and frequency standard receivers. It communicates with the receiver using the SCPI command set via the USB port. This utility can be obtained directly from Real Ham Radio.com at the following URL:

http://www.realhamradio.com/gpscon-buy-now.htm

Important note: On newer, faster computers running Windows 7, GPSCon may not acquire data correctly. If you encounter this problem, it is recommended that you install GPSCon on a slower computer using Windows XP, or try running GPSCon in Windows XP compatibility mode.

3.2 Z38XX Utility

3.2.1 Installation and Set Up

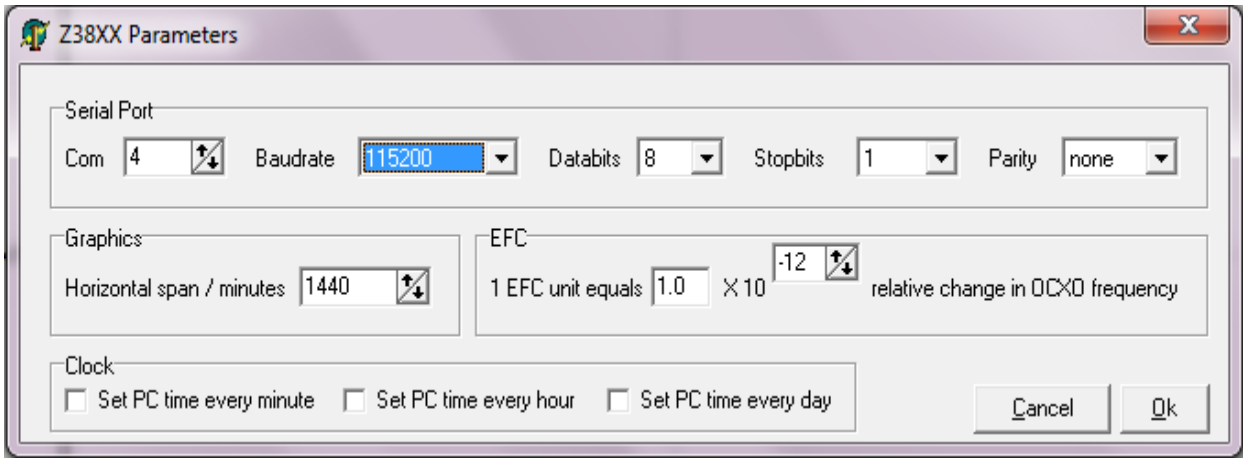
The Z38XX manual has instructions on how to install and set up the software. All the information needed to run the program is available in the included user manual. Only some details of setup and use will be provided here for convenient reference.

© 2014 Jackson Labs Technologies, Inc.

3.2.1.1 Parameter Setup

Before communication with Z38XX can take place, the communications parameters must be set. To do so, click on the Parameters tab. The parameter window will appear as shown in Figure 3.1.

Figure 3.1 Z38XX parameter window



Set the communications parameters as follows:

- Comm port: Windows will assign a comm port. Enter that number in the Com box.
- Baudrate: 115,200
- Data bits: 8 bits
- Stop bits: 1
- Parity: none

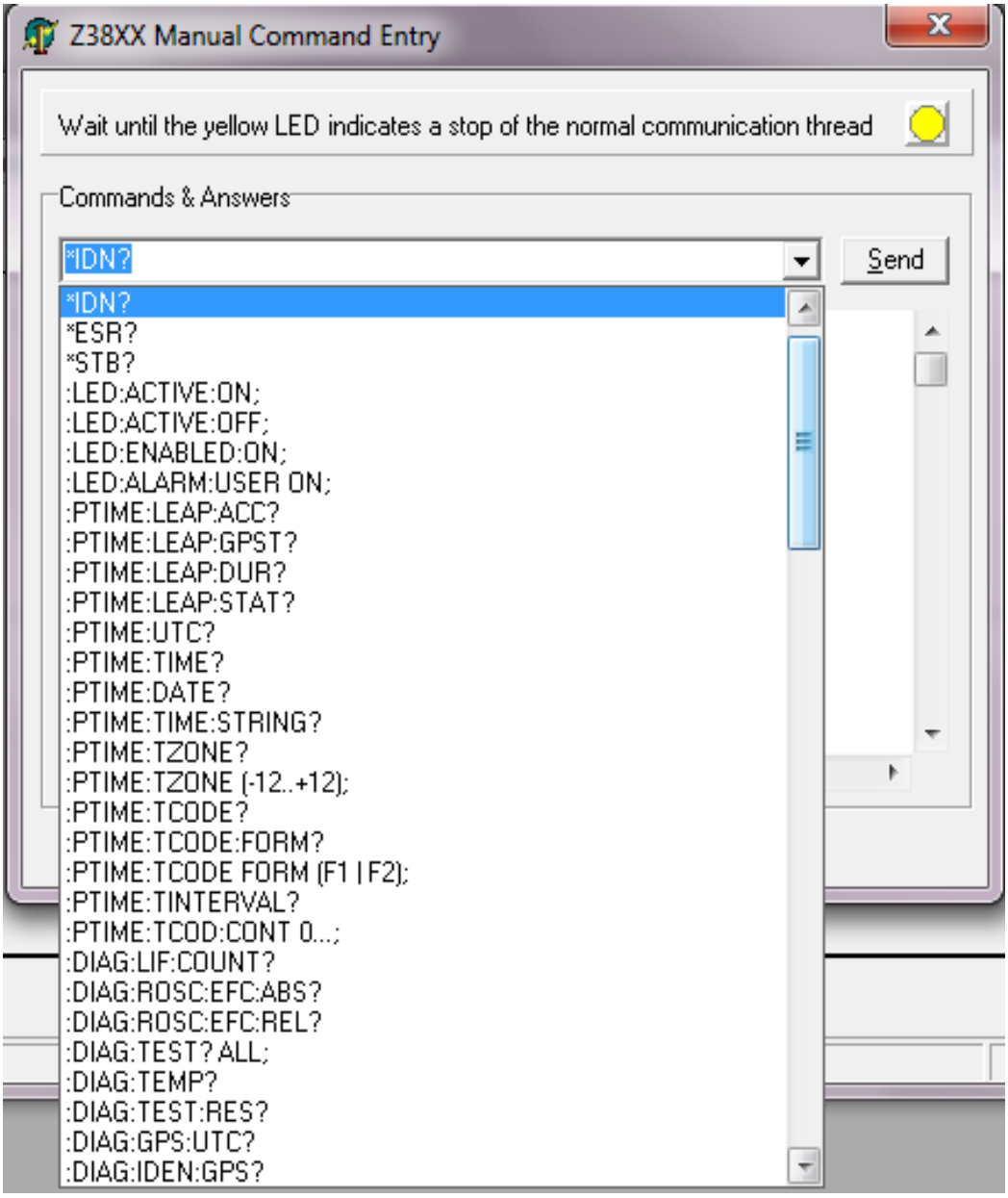
3.2.1.2 Serial Echo

For serial communication with Z38XX to work correctly, Serial Echo must be turned off (see the explanation in the Z38XX manual). To turn off serial echo, click on the Manual Command Entry tab. The drop-down menu shown in Figure 3.2 will appear. Scroll all the way down and click on SYST:COMM:SER:ECHO OFF. Wait until the yellow indicator is lit and then press “Send”. This will send a command to the GPSTCXO and turn off serial echo.

Note: If you want to run GSPcon utility subsequently, be sure and turn back on Serial Echo as that program requires it. To do so, click on the Manual Command Entry tab and scroll down to the menu item SYST:COMM:SER:ECHO ON. Wait until the yellow indicator is lit and then press ”Send”.

© 2014 Jackson Labs Technologies, Inc.

Figure 3.2 Manual Command window



3.2.1.3 Windows Compatibility

Z38XX may not operate properly under the Windows Vista or Windows 7 operating systems. It is best to start these versions of Windows in XP Compatibility Mode. This will ensure proper operation of the program. Of course, you can try running under Windows Vista or 7 as it does work on some systems.

© 2014 Jackson Labs Technologies, Inc.

3.2.2 Running the program

When Z38XX starts up, the main window appears, as shown in Figure 3.3. The window can be moved or resized as desired. It is necessary to wait about 20 seconds after starting the program for the software to establish communications with the GPSTCXO.

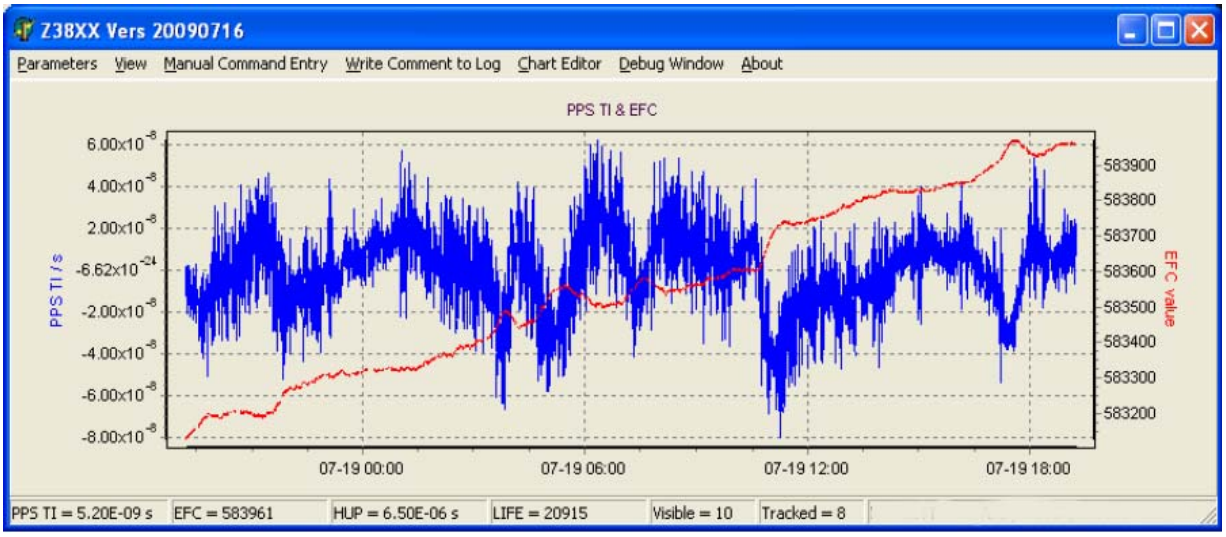
The main graph shows the EFC (Electronic Frequency Control) digital control value (scale on the right) in red, and the GPSR 1pps TI (compared with the mean GPS derived 1pps) in blue (scale on the left). The graph is auto-scaling on both parameters.

3.2.2.1 Zoom and Pan

In the main graph window, you can zoom in to get more detail. To do so, position the cursor at the bottom or top of the screen next to the beginning of the area you wish to zoom in on. Using the left mouse button, drag the cursor up and to the right (or down and to the left) to the end of the desired zoom area. When you release the mouse button, the display will zoom in on the desired area. To unzoom, drag the cursor in the opposite direction, from the bottom right up and left (or from the top down and left). The display will return to the full graph again.

To pan within the graph display, use the right mouse button to drag the graph around the window.

Figure 3.3 Z38XX main window



3.2.3 View menu

The View menu allows you to view different aspects of the GPSTCXO performance such as:

- Satellite Azimuth/Elevation Chart
- Satellite C/N level Chart
- Time Stability measures
- Clock Display
- EFC Statistics
- Receiver Status

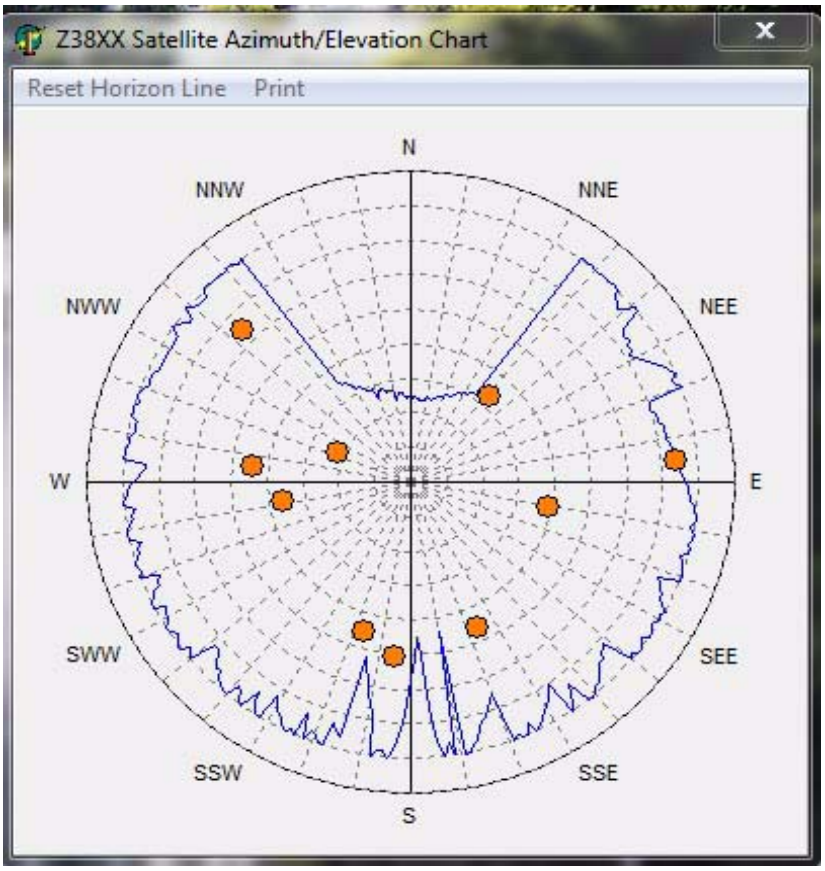
© 2014 Jackson Labs Technologies, Inc.

- Status Log
- Error Log

3.2.3.1 Satellite Azimuth/Elevation Chart

From the drop-down View menu select Satellite Azimuth/Elevation Chart. You will see a polar graph like the one shown in Figure 3.4. It may take a few hours for the graph to display all the satellites within your antenna's view. The chart changes over time as the satellites move in and out of view.

Figure 3.4 Satellite Azimuth/Elevation chart

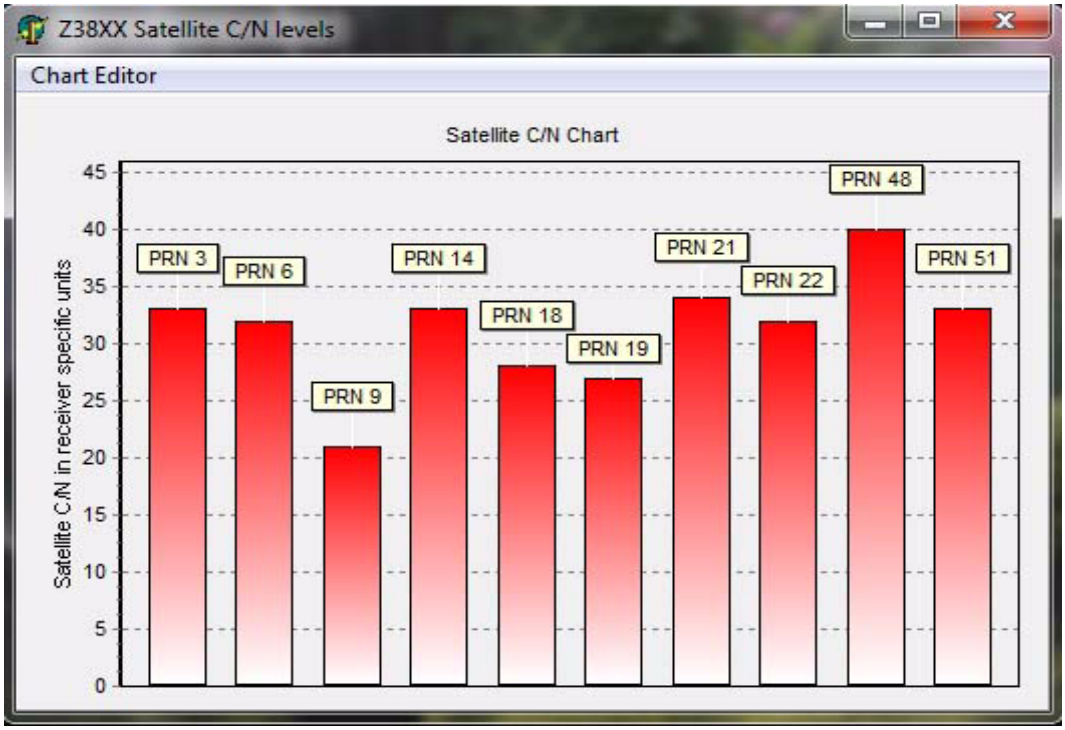


3.2.3.2 Satellite C/N level Chart

Select Satellite C/N level Chart from the View menu and observe the chart shown in Figure 3.5. This graph show the Carrier to Noise ratio of each satellite being tracked.

© 2014 Jackson Labs Technologies, Inc.

Figure 3.5 Satellite C/N/chart



3.2.3.3 Holdover Uncertainty & Sats

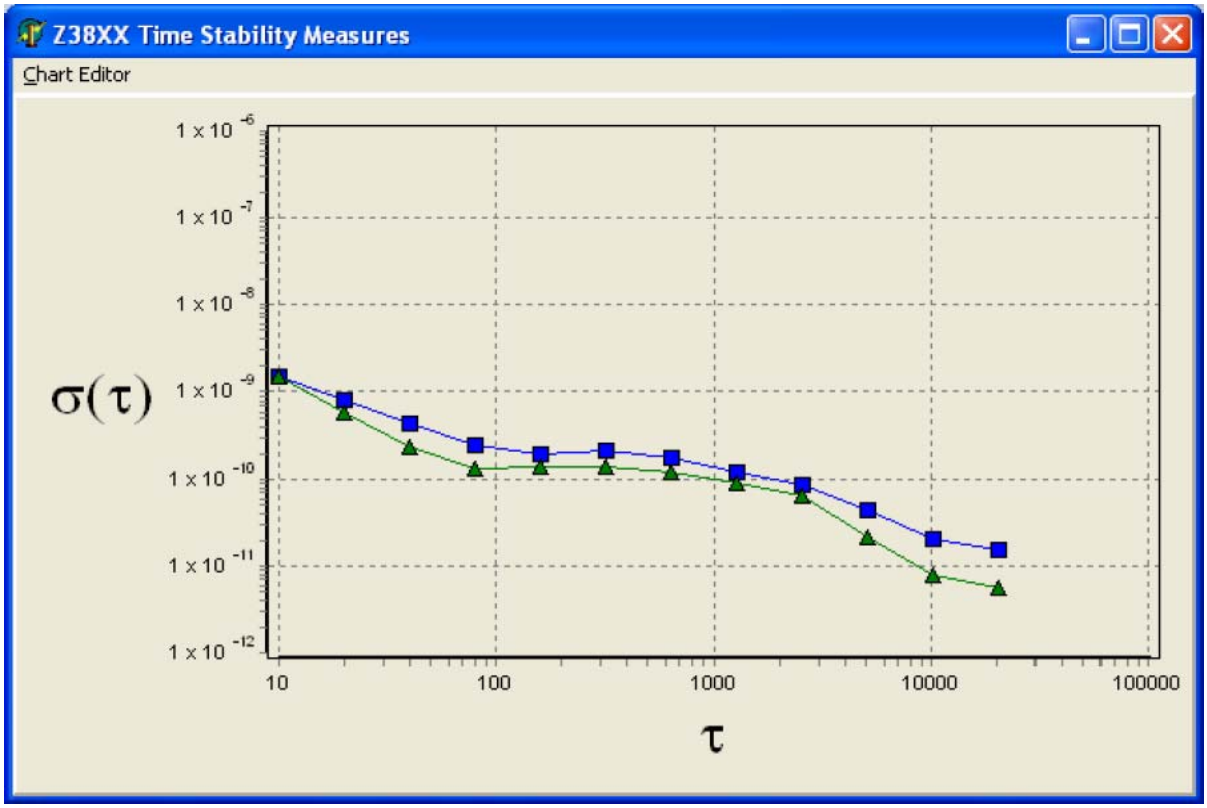
These parameters are not supported by the GPSTCXO.

3.2.3.4 Time Stability Measures

Select Time Stability Measures from the View menu to bring up the chart shown in Figure 3.6. This chart is primarily used to display the Allan Deviation for the GPSTCXO. To learn more about the different display parameters for this window, please consult the Z8XX User Manual.

© 2014 Jackson Labs Technologies, Inc.

Figure 3.6 Time Stability measures window



3.3 GPScon Utility

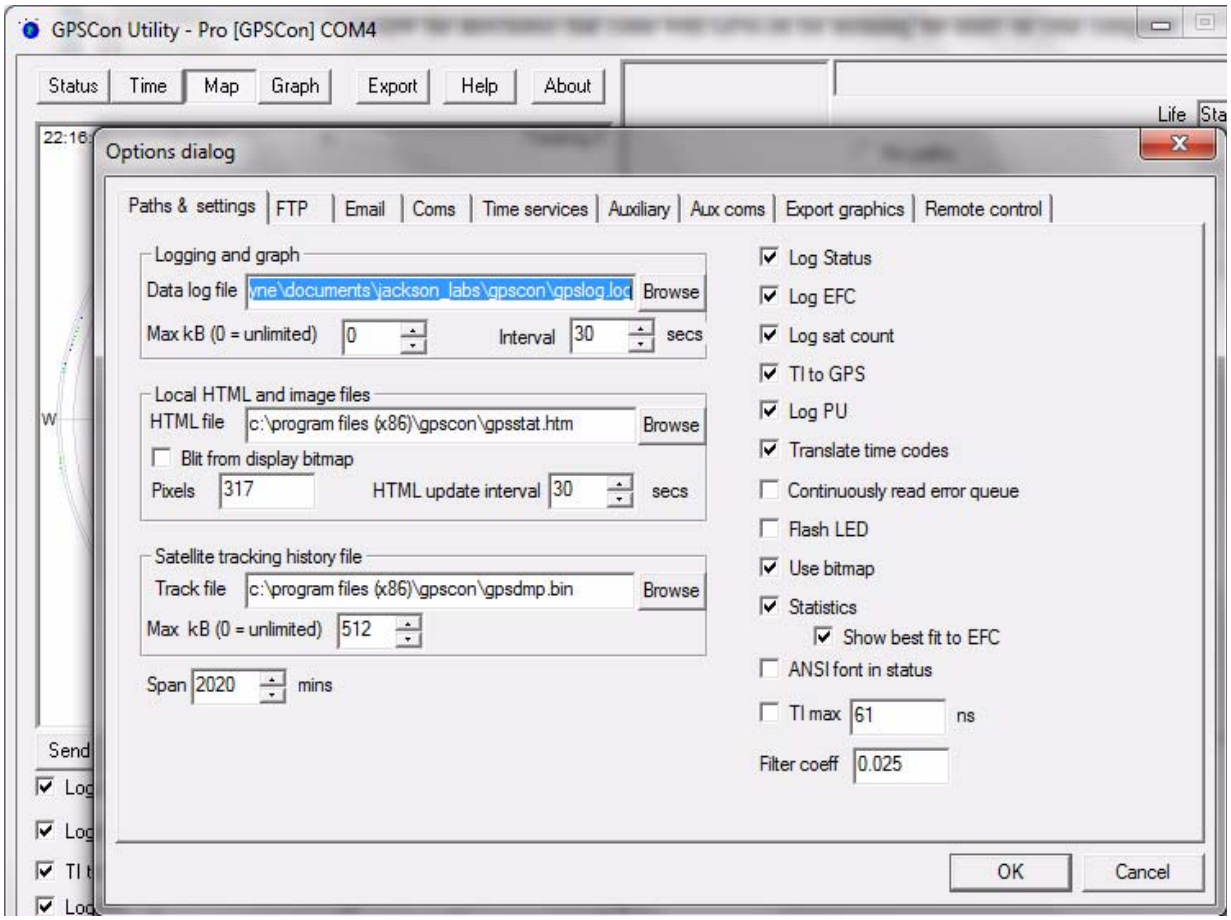
3.3.1 Installation and Set Up

Follow the directions that come with GPSCon for installing the utility on your computer. The GPSCon utility has a help file that should be consulted in order to get the full functionality of this utility. Only a few of the features and commands are mentioned in this chapter for convenience.

3.3.1.1 Setting the options

To set up the options for your GPSCon session, press the “Options” button below the display area. The window shown in Figure 3.7 will appear. You can select from the tabs which options you wish to set.

Figure 3.7 Options window



3.3.1.2 Communication Parameters

Before you can use GPSCon you must set the communication parameters for your system. Open the dialog box by pressing the “Options” button. Then select the “Coms” tab. You will see the window shown in Figure 3.8.

© 2014 Jackson Labs Technologies, Inc.

Set the communications parameters as follows:

- Comm port: Windows will assign a comm port. Enter that number in the Com box.
- Baudrate: 115,200
- Data bits: 8 bits
- Stop bits: 1
- Parity: none
- Flow Control: “None”

Once you have configured the communication parameters, press the “OK” button to close the window.

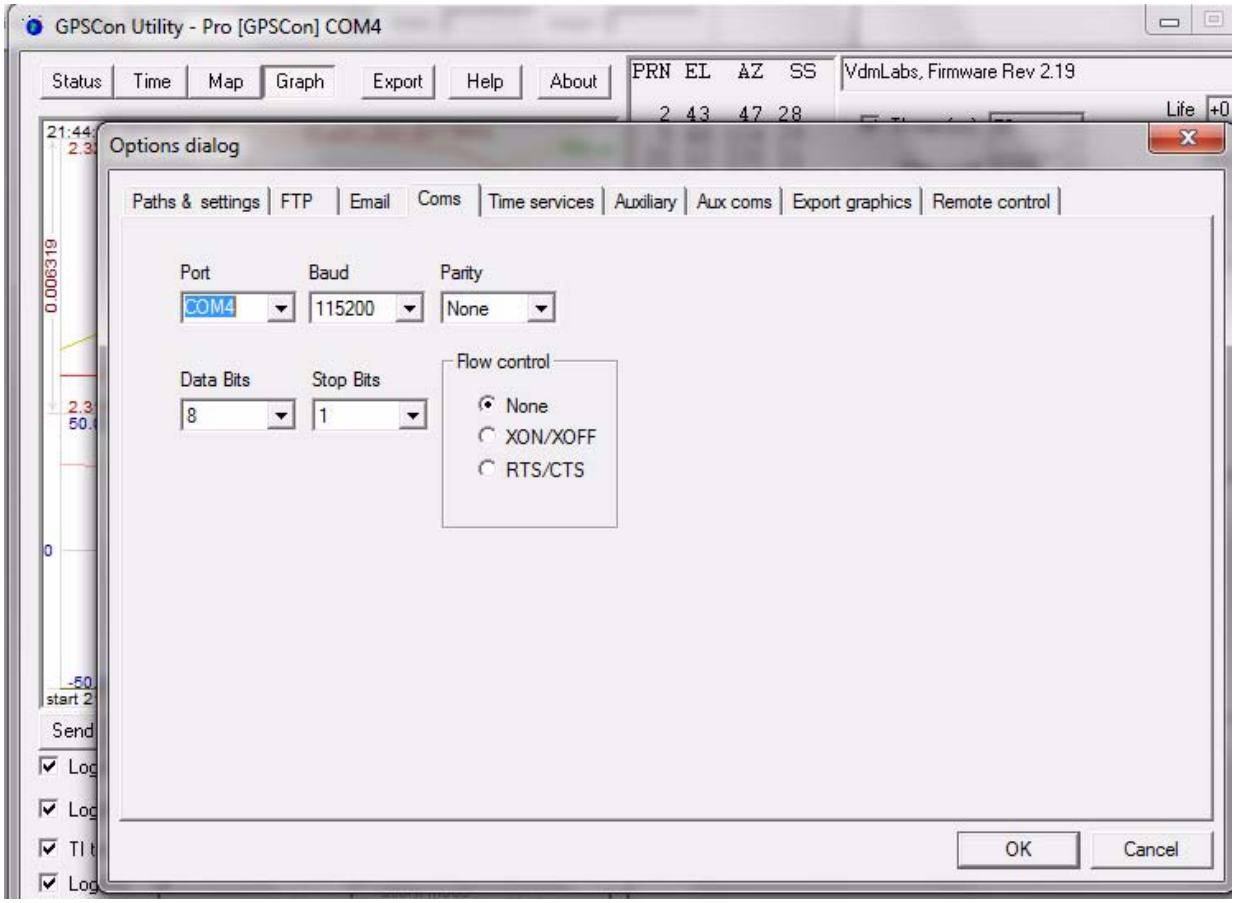
For proper communication between the GPSTXCO and GPScon, SYST:COMM:SER:ECHO must be set to ON. Although this is the factory default, it could have been set to OFF for use with the Z38XX utility. To set it to ON, open the manual command dialog box (see Section 3.3.2). Manually enter the command SYST:COMM:SER:ECHO ON and press the Send button.

3.3.1.3 Auxiliary parameters

After pressing the “Options” button, you can select “Auxiliary” and set other options or measurements. See Figure 3.9 for an example of an auxiliary measurement. You will notice that the “Aux 1 request string” has been set to `meas:current?<CD>` and the “Log Aux1” box is checked. In the area below labeled “Traces to be visible on the graph”, the box “Aux 1” is checked and the label “OCXO curr” has been added.

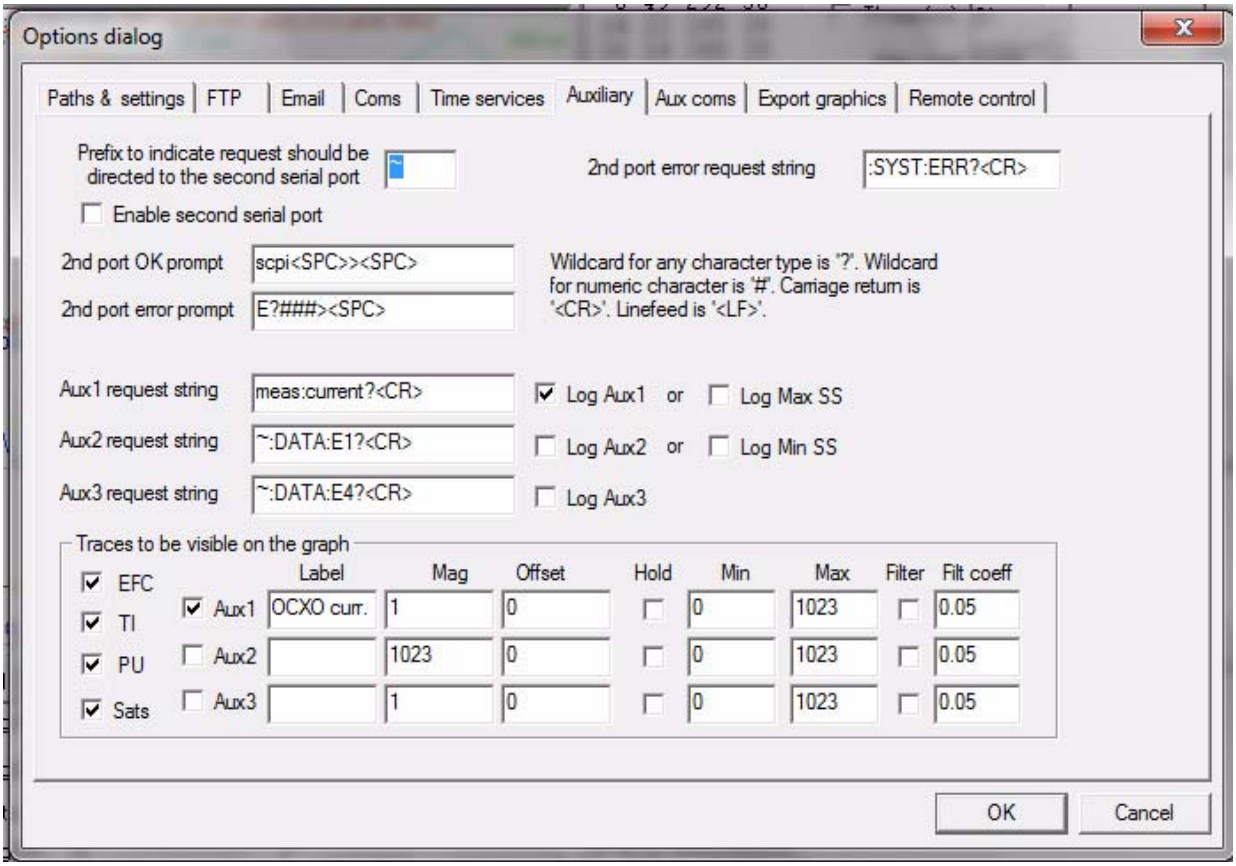
© 2014 Jackson Labs Technologies, Inc.

Figure 3.8 Setting the communications parameters



© 2014 Jackson Labs Technologies, Inc.

Figure 3.9 Auxiliary Parameters window



3.3.1.4 Other options

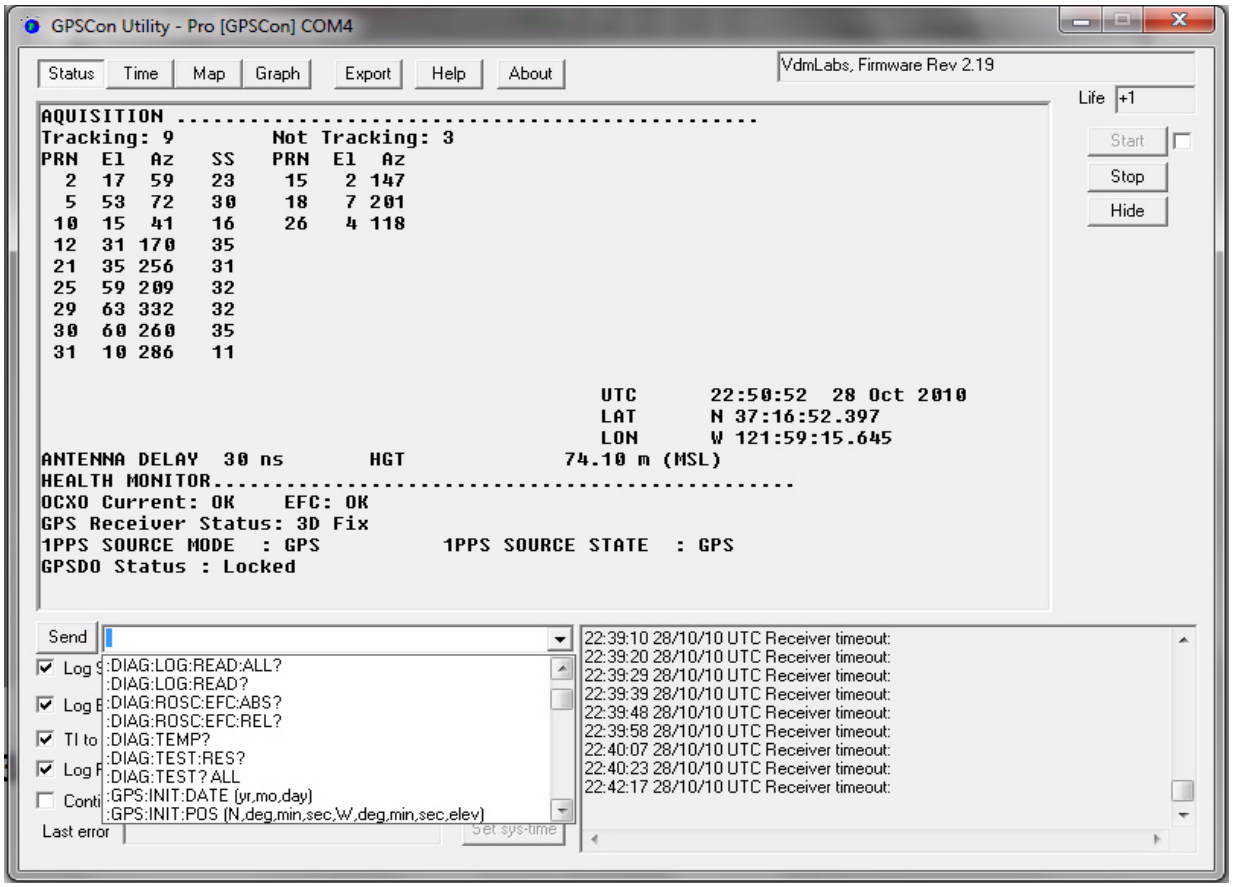
The other tabs in the options window can be selected and you can set whatever options you need, such as paths for logging or exporting graphics.

3.3.2 Sending manual commands to the receiver

You can send SCPI commands manually by using the drop-down box under the display window as shown in Figure 3.10. Care must be taken when sending these commands so be sure that the command that you select is supported by the LC-XO-PLUS GPSDO GPSDO. Once you've selected the command, you can press "Send" to send it to the LC-XO-PLUS GPSDO.

© 2014 Jackson Labs Technologies, Inc.

Figure 3.10 Sending manual commands



3.3.3 Use of the mouse in graph mode

Refer to Figure 3.11 for the following description. In graph mode the span of the graph may be set using the span setting. Alternatively, the start and or stop time of the graph may be locked using the mouse. Set the start time by left clicking on the desired start point. If you wish, the stop time may also be locked by right clicking the desired stop point. This can all be unlocked by left double-clicking anywhere on the graph. Double-click always causes all of the selected span data to be displayed. At the next update cycle, the selected span, if not set to zero, will be enforced. However, the left click, and if chosen the right click, always overrides the span setting.

To display all of the data in the file without manually setting the span to zero, you should right double-click in the graph. This has the effect of setting the start time to zero, the stop time to infinity, and asserting the mouse override condition. To release, left double-click.

Since this is harder to describe than to actually do, here is a paraphrase of the above:

"To zoom in: The mouse is used to set the left extent and the right extent of the portion of the curve that the user wants to fill the screen. Click once with the left mouse button on the point that marks the left side of what you want to be the magnified curve. Immediately that point becomes the left end of the curve. Then similarly click the right mouse button on the curve at the time you wish to be the right most portion of the magnified curve and it immediately becomes the end point on the right side. And, finally to return to the zoomed out ("fit to window") view, left double-click on the curve."

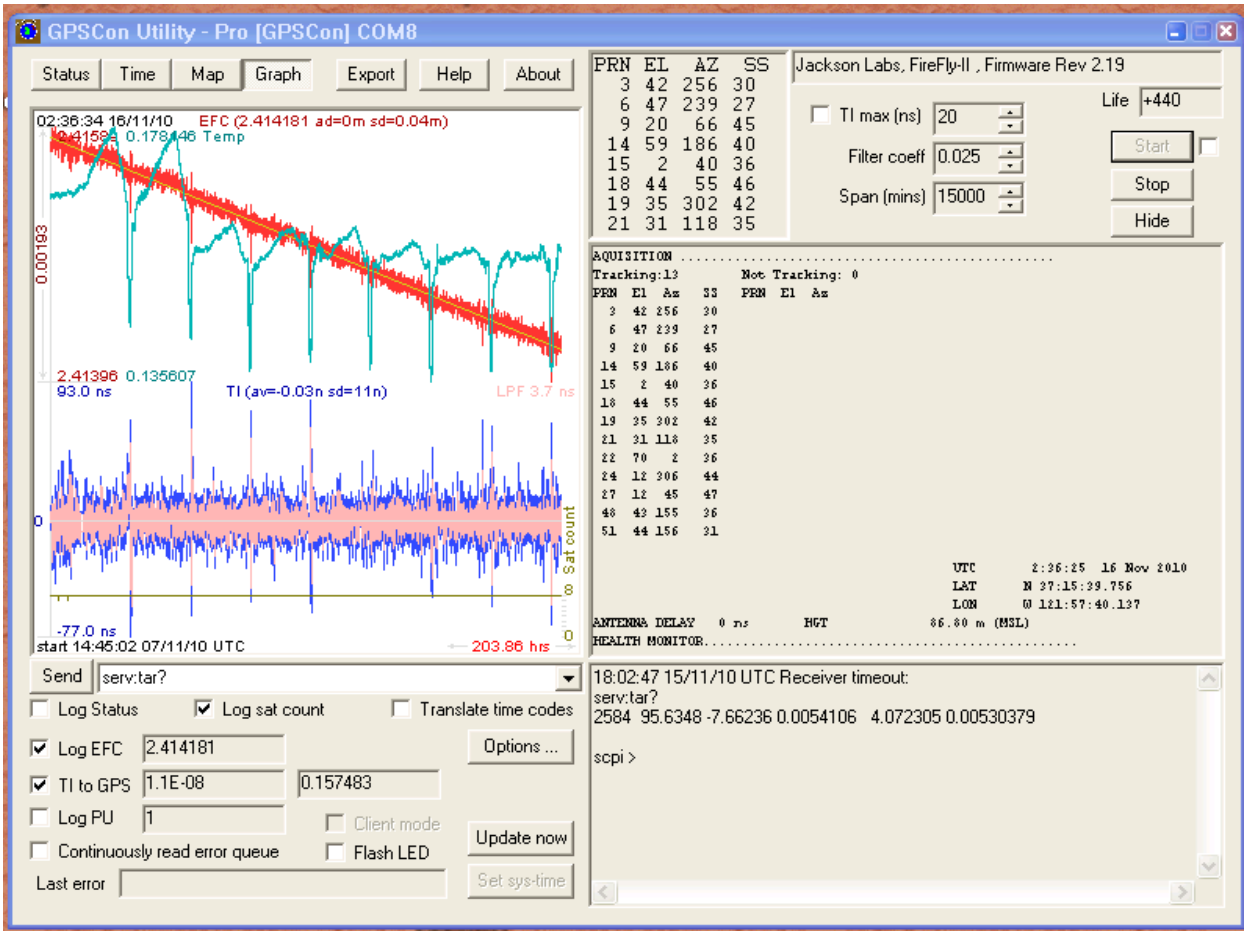
© 2014 Jackson Labs Technologies, Inc.

Remember, in order to see all the data in the log file, you must either set the span control to zero, or right double-click in the graph.

When you have locked the start and stop time using the mouse, you can scroll left or right through the data without changing the span. To scroll to a later time, use Shift + Left click. To scroll to an earlier time, use Shift + Right click. Double left click to release everything.

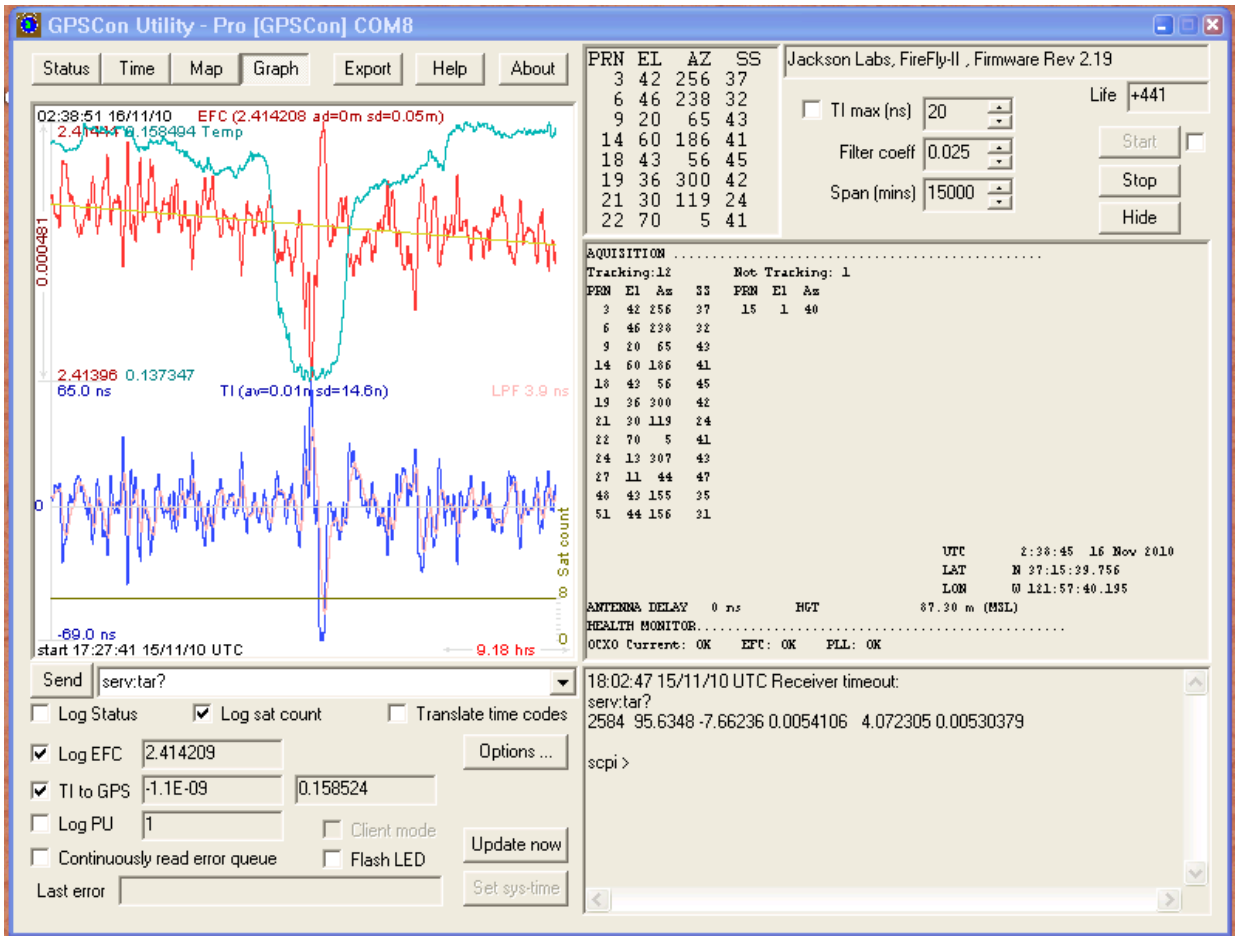
The time span indication at the lower right of the graph will turn red to signify that mouse override is in effect.

Figure 3.11 Graph display



© 2014 Jackson Labs Technologies, Inc.

Figure 3.12 Expanded Graph Display



3.3.4 Exporting the graphics

The settings which control the mode of the Export function are contained in the Options dialog.

Export allows you to create an image file of either the graph or the satellite map. You select which you want using the radio buttons. If you select 'Graph', you have the option to export only that which is currently visible, or to export the graph which is a plot of the entire logfile contents. Use the checkbox "All" to make this choice.

You may nominate a size in X and Y. The file format may be .BMP, .JPG, .GIF, or .PNG. Your settings will be stored and will be the default next time you open this dialog.

If you choose to export the graph, you might want to override the TI max setting in force on the screen display. You may do this by entering a non-zero value into the 'Override TI' control. A value of zero causes the export to take the same setting if any as the screen display.

The export may be done automatically on a timed basis. Simply enter a non-zero value in seconds to choose an export time interval. To manually export in accordance with the settings, press the 'Export' button.

© 2014 Jackson Labs Technologies, Inc.

3.4 Interpreting the Data

Figure 3.11 shows the data acquired by the LC-XO-PLUS GPSDO unit over a period of more than 200 hours The red trace is EFC (crystal frequency control voltage). The crystal is aging (becoming faster in frequency over time). This requires the control voltage to be lowered to maintain 10.0MHz exactly. A drift of ~2mV is visible over 200 hours. On the left side of the screen the EFC range over this 200 hour plot is displayed vertically as 0.00193V. This means the drift of the EFC voltage due to aging is ~88mV per year. The EFC sensitivity of the crystal is about 8Hz per volt, so the crystal ages at:

8Hz/V * 0.088V/Year = 0.704Hz/Year drift.

At 10MHz:

0.704Hz / 10MHz = 7.04E-08 aging rate per year.

This is the same as 0.2ppb drift due to aging per day.This crystal aging is fully compensated by the firmware with and without GPS reception of course.

The OCXO heater current is shown in turqoise. We can see it ranges from 0.135607A to 0.178146A. The OCXO current jumps lower every 24 hours because the unit is sitting next to a window, and the sun shines onto the OCXO in the evenings, heating it up, and thus making the unit use lower power during that event.

In Figure 3.12, which is a zoom of Figure 3.11, we can see the phase offset error of the internal OCXO to the UTC GPS reference. We can see the maximum drift is -77ns to +93ns. The average is (TI av=-0.03ns). The standard deviation over the 200 hour plot is sd=11ns. This means the average error of the 10MHz phase of this unit over 200 hours is only +/-11ns rms. Or, in other words the average jitter (wander) over 200 hours of operation is:

11ns / 200Hrs = 1.528E-014

or in other words the unit performs as well as a high quality Cesium Atomic reference clock over long periods of time. The unit disciplines its internal 10MHz reference to within less than +/-80ns peak to peak of UTC at all times, which is less than one complete clock cycle at 10MHz.

© 2014 Jackson Labs Technologies, Inc.

3.5 Performance

Some typical performance parameters for the LC-XO-PLUS GPSDO are shown in the following figures.

Figure 3.13 shows the typical Allan Deviation performance of the LC-XO-PLUS GPSDO after one week of burn-in, locked to GPS and shielded from airflow. Corrections from the GPS receiver improve the short term phase stability of the TCXO oscillator above 50-second averaging times.

Figure 3.13 Typical LC-XO-Plus Allan Deviation

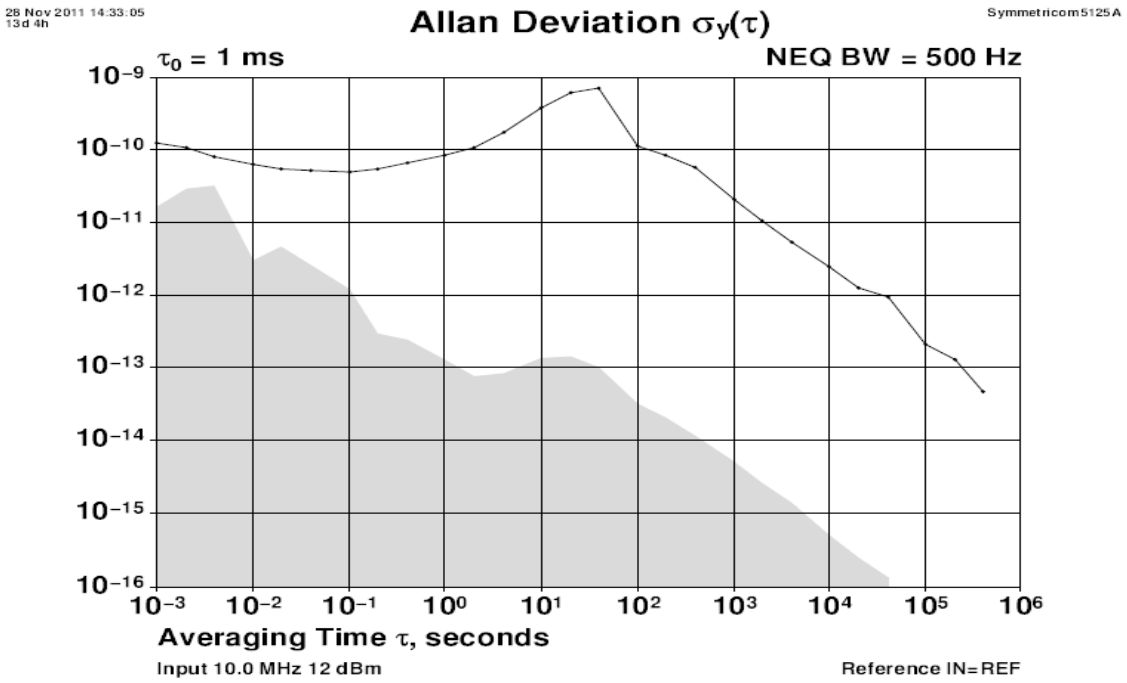
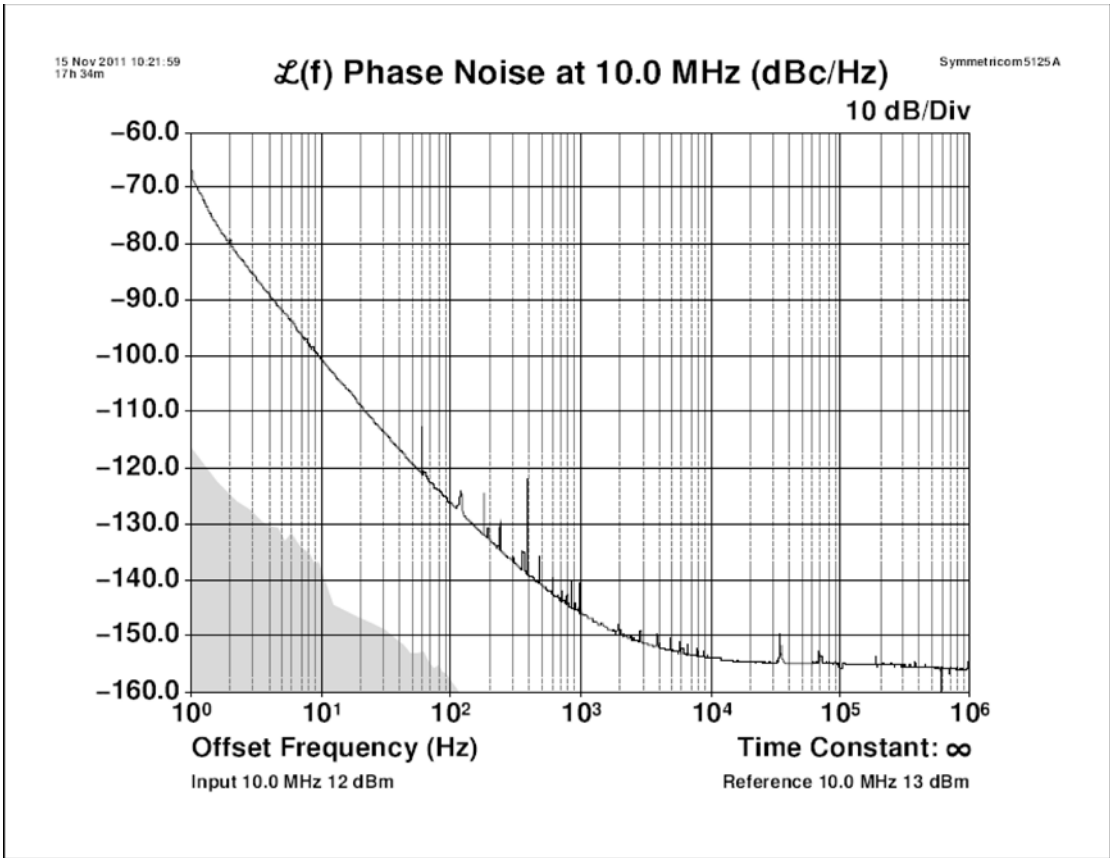


Figure 3.14 is a plot of typical LC-XO-PLUS GPSDO phase noise performance while locked to GPS. The noise floor can be seen to be below -155dBc.

© 2014 Jackson Labs Technologies, Inc.

Figure 3.14 Typical LC-XO-Plus Phase Noise



© 2014 Jackson Labs Technologies, Inc.

© 2014 Jackson Labs Technologies, Inc.

4 SCPI-Control Quick Start Instructions

4.1 Introduction

The SCPI (**S**tandard **C**ommands for **P**rogrammable **I**nstrumentation) subsystem is accessed via the USB RS-232 interface and a terminal program. By default the terminal settings are 115200, 8N1. Use terminal programs such as TeraTerm (recommended) or Hyperterm, or use the command and control window functions of Z38xx or GPSCon application programs to send commands to the LC-XO-PLUS unit.

There are a number of commands that can be used as listed below. Most of these are identical or similar to Symmetricom 58503A commands.To get a listing of the available commands, send the HELP? query. This will return a list of all the available commands for the LC-XO-PLUS GPSDO.

Additional information regarding the SCPI protocol syntax can be found on the following web site:

http://www.scpiconsortium.org

Please refer to the document SCPI-99.pdf for details regarding individual SCPI command definitions. A basic familiarity with the SCPI protocol is recommended when reading this chapter.

4.2 General SCPI Commands

4.2.1 *IDN?

This query outputs an identifying string. The response will show the following information:

<company name>, <model number>, <serial number>, <firmware revision>

4.2.2 HELP?

This query returns a list of the commands available for the LC-XO-PLUS GPSDO.

© 2014 Jackson Labs Technologies, Inc.

4.3 GPS Subsystem

Note: Please note that LC-XO-PLUS unit displays antenna height in MSL Meters rather than in GPS Meters on all commands that return antenna height [the legacy Fury GPSDO uses GPS height].

The GPS subsystem regroups all the commands related to the control and status of the GPS receiver. The list of the commands supported is the following :

GPS:SATellite:TRAcking:COUNt?

GPS:SATellite:VISible:COUNt?

GPS:GPGGA <int> [0,255]

GPS:GGASTat <int> [0,255]

GPS:GPRMC <int> [0,255]

GPS:XYZSPeed <int> [0,255]

GPS:POSition?

GPS:RESET ONCE

GPS

4.3.1 GPS:SATellite

This group of commands describe the satellite constellation.

4.3.2 GPS:SATellite:TRAcking:COUNt?

This query returns the number of satellites being tracked.

4.3.3 GPS:SATellite:VISible:COUNt?

This query returns the number of satellites (PRN) that the almanac predicts should be visible, given date, time, and position.

4.3.4 NMEA Support

The following two commands allow the LC-XO-PLUS GPSDO to be used as an industry standard navigation GPS receiver. The GPGGA and GPRMC NMEA commands comprise all necessary information about the antenna position, height, velocity, direction, satellite info, fix info, time, date and other information that can be used by standard navigation applications via the LC-XO-PLUS GPSDO RS-232 interface.

Once enabled, LC-XO-PLUS GPSDO will send out information on the RS-232 transmit pin automatically every N seconds. All incoming RS-232 commands are still recognized by LC-XO-PLUS GPSDO since the RS-232 interface transmit and receive lines are completely independent of one another.

© 2014 Jackson Labs Technologies, Inc.

Please note that the position, direction, and speed data is delayed by one second from when the GPS receiver internally reported these to the LC-XO-PLUS GPSDO Microprocessor, so the position is valid for the 1PPS pulse previous to the last 1PPS pulse at the time the data is sent (one second delay). The time and date are properly output with correct UTC synchronization to the 1PPS pulse immediately prior to the data being sent.

Once set, the following two commands will be stored in NV memory, and generate output information even after power to the unit has been cycled.

4.3.5 GPS:GPGGA

This command instructs the LC-XO-PLUS GPSDO to send the NMEA standard string $GPGGA every N seconds, with N in the interval [0,255]. The command is disabled during the initial 4 minute OCXO warmup phase.

This command has the following format:

GPS:GPGGA <int> [0,255]

GPGGA shows height in MSL Meters, this is different from traditional GPS receivers that display height in GPS Meters. The difference between MSL and GPS height can be significant, 35m or more are common.

4.3.6 GPS:GGASTat

This command instructs the LC-XO-PLUS GPSDO to send a modified version of the NMEA standard string $GPGGA every N seconds, with N in the interval [0,255]. The command is disabled during the initial 7 minute OCXO warmup phase.

This command has the following format:

GPS:GGASTat <int> [0,255]

This command replaces the regular NMEA GGA validity flag with a decimal number indicating the lock-state of the unit. Please see section SERVo:TRACe for a detailed description of the lock state variable. The command allows capture of the position and other information available in the GGA command, as well as tracking the lock state and health of the unit's OCXO performance.

GGASTat shows height in MSL Meters, this is different from traditional GPS receivers that display height in GPS Meters. The difference between MSL and GPS height can be significant, 35m or more are common.

4.3.7 GPS:GPRMC

This command instructs the LC-XO-PLUS GPSDO to send the NMEA standard string $GPRMC every N seconds, with N in the interval [0,255]. The command is disabled during the initial 4 minute OCXO warmup phase.

This command has the following format:

GPS:GPRMC <int> [0,255]

© 2014 Jackson Labs Technologies, Inc.

4.3.8 GPS:XYZSPeed

Firmware version 0.909 and later add a 3D velocity vector output command. Enabling this command will output a 3 dimensional velocity vector indicating the unit's speed in centimeters per second as well as the Time Of Week in milliseconds.

X, Y, and Z speed are individually given, and are independent of each other. An accuracy estimate in centimeters per second is also given. The velocity data is time-stamped using the time-of-week with a resolution of milliseconds. Use the following format to generate the velocity vector every N seconds, with N in the interval [0,255]:

GPS:XYZSPeed <int> [0,255]

4.3.9 GPS:POSition?

This command will return the position and height of the GPS antenna, including velocity and track over ground.

4.3.10 GPS:RESET ONCE

This command will re-initialize the GPS receiver.

4.3.11 GPS?

This query displays the configuration, position, speed, height and other relevant data of the GPS receiver in one convenient location.

4.4 PTIME Subsystem

The PTIME subsystem regroups all the commands related to the management of the time.The list of the commands supported is the following :

PTIMe:TZONe?

PTIMe:DATE?

PTIMe:TIME?

PTIMe:TIME:STRing?

PTIMe:TINTerval?

PTIME?

4.4.1 PTIMe:TZONe?

Returns the local time zone offset.

© 2014 Jackson Labs Technologies, Inc.

4.4.2 PTIMe:DATE?

This query returns the current calendar date. The local calendar date is referenced to UTC time. The year, month, and day are returned.

4.4.3 PTIMe:TIME?

This query returns the current 24-hour time. The local time is referenced to UTC time. The hour, minute, and second is returned.

4.4.4 PTIMe:TIME:STRing?

This query returns the current 24-hour time suitable for display (for example, 13:24:56).

4.4.5 PTIMe:TINTerval?

This query is equivalent to the command SYNChronization:TINTerval

4.4.6 PTIME?

This query returns at once the result of the four following queries:

PTIME:DATE?

PTIME:TIME?

PTIME:TZONE?

PTIME:TINTerval?

4.5 SYNChronization Subsystem

This subsystem regroups the commands related to the synchronization of the LC-XO-PLUS GPSDO with the GPS receiver. The list of the commands supported for this subsystem is the following:

SYNChronization:SOURce:MODE [GPS|EXTernal|AUTO]

SYNChronization:SOURce:STATE?

SYNChronization:HOLDover:DURation?

SYNChronization:HOLDover:INITiate

SYNChronization:HOLDover:RECovery:INITiate

SYNChronization:TINTerval?

SYNChronization:IMMEdiate

SYNChronization:FEEstimate?

SYNChronization:LOCKed?

SYNChronization?

© 2014 Jackson Labs Technologies, Inc.

4.5.1 SYNChronization:SOURce:MODE [GPS|EXTernal|AUTO]

The board may be configured lock to an external 1PPS source, or the internal GPS receiver. Pin 4 of the connector J6 labeled “DEBUG” on the PCB may be used to feed an external CMOS rising-edge 1PPS signal with 0V < x <5V signal level, and 1us minimum pulse width into the unit. Use pin 5, 7, 9, or 11 of Debug connector J6 on the PC-board as a 1PPS signal return.

By default the unit is set to GPS. It may be hard-coded to only use the external 1PPS source by setting EXT, or it may be auto-switched to the external 1PPS signal if the internal GPS receiver does not generate 1PPS pulses for longer than 15 seconds if the signal is too week, or there is a GPS failure. When set to the AUTO setting, the unit will switch back to the internal GPS receiver once 1PPS pulses are generated internally again.

4.5.2 SYNChronization:HOLDover:DURation?

This query returns the duration of the present or most recent period of operation in the holdover and holdover processes. This is the length of time the reference oscillator was not locked to GPS. The time units are seconds. The first number in the response is the holdover duration. The duration units are seconds, and the resolution is 1 second. If the Receiver is in holdover, the response quantifies the current holdover duration. If the Receiver is not in holdover, the response quantifies the previous holdover. The second number in the response identifies the holdover state. A value of 0 indicates the Receiver is not in holdover; a value of 1 indicates the Receiver is in holdover.

4.5.3 SYNChronization:HOLDover:INITiate

The command will place the unit into a forced holdover state, while still indicating the difference between the internal 1PPS generated by the OCXO and the GPS generated 1PPS. This command is useful to measure the OCXO drift when in holdover. Please note that the Time Interval Counter is limited to +/-2000ns display range. The time interval difference may be displayed with the SYNC? command.

4.5.4 SYNChronization:HOLDover:RECovery:INITiate

This command terminates a manual holdover that was initiated with the SYNC:HOLD:INIT command, and return the unit to normal GPS locking mode.

4.5.5 SYNChronization:TINTerval?

This query returns the difference or timing shift between the LC-XO-PLUS GPSDO 1 PPS and the GPS 1 PPS signals. The resolution is 1E-10 seconds.

4.5.6 SYNChronization:IMMEdiate

This command initiates a near-instantaneous alignment of the GPS 1 PPS and Receiver output 1 PPS. To be effective, this command has to be issued while not in holdover.

© 2014 Jackson Labs Technologies, Inc.

4.5.7 SYNChronization:FEEstimate?

This query returns the Frequency Error Estimate, similar to the Allan Variance using a 1000s measurement interval and comparing the internal 1PPS to GPS 1PPS offset.

Values less than 1E-012 are below the noise floor, and are not significant.

4.5.8 SYNChronization:LOCKed?

This query returns the lock state (0=OFF, 1=ON) of the PLL controlling the OCXO.

4.5.9 SYNChronization:health?

The SYNChronization:health? query returns a hexadecimal number indicating the system's health-status. Error flags are encoded in a binary fashion so that each flag occupies one single bit of the binary equivalent of the hexadecimal health-status flag.

The following system parameters are monitored and indicated through the health-status indicator. Individual parameters are 'ored' together which results in a single hexadecimal value encoding the following system status information:

If the OCXO coarse-DAC is maxed-out at 255	HEALTH STATUS |= 0x1;
If the OCXO coarse-DAC is mined-out at 0	HEALTH STATUS |= 0x2;
If the phase offset to UTC is >250ns	HEALTH STATUS |= 0x4;
If the run-time is < 300 seconds	HEALTH STATUS |= 0x8;
If the GPS is in holdover > 60s	HEALTH STATUS |= 0x10;
If the Frequency Estimate is out of bounds	HEALTH STATUS |= 0x20;
If the OCXO voltage is too high	HEALTH STATUS |= 0x40;
If the OCXO voltage is too low	HEALTH STATUS |= 0x80;
If the short-term-drift (ADEV @ 100s) > 100ns	HEALTH STATUS |= 0x100;
For the first 7 minutes after a phase-reset, or a coarsedac change:	HEALTH STATUS |= 0x200;

As an example, if the unit is in GPS holdover, and the OCXO voltage is too high, and the UTC phase offset is > 250ns then the following errors would be indicated:

1) UTC phase > 250ns: 0x4

2) OCXO voltage too high: 0x40

3) GPS in holdover: 0x10

'Oring' these values together results in:

© 2014 Jackson Labs Technologies, Inc.

0x40 | 0x10 | 0x4 = 0x54

The unit would thus indicate: **HEALTH STATUS: 0x54**

A health status of 0x0 indicates a properly locked, and warmed-up unit that is completely healthy.

4.5.10 SYNChronization?

This query returns the results of these six queries :

SYNChronization:SOURce:MODE?

SYNChronization:SOURce:STATE?

SYNChronization:LOCKed?

SYNChronization:HOLDover:DURation?

SYNChronization:FEEstimate?

SYNChronization:TINTerval?

SYNChronization:health?

4.6 DIAGnostic Subsystem

This subsystem regroups the queries related to the diagnostic of the OCXO.The list of the commands supported for this subsystem is as follows:

DIAGnostic:ROSCillator:EFControl:RELative?

DIAGnostic:ROSCillator:EFControl:ABSolute?

4.6.1 DIAGnostic:ROSCillator:EFControl:RELative?

This query returns the Electronic Frequency Control (EFC) output value of the internal reference oscillator. It returns a percentage value between -100% to +100%. :

4.6.2 DIAGnostic:ROSCillator:EFControl:ABSolute?

This query returns the Electronic Frequency Control (EFC) output value of the internal reference oscillator. It returns a value in volts between 0 and 5 V

4.7 MEASURE Subsystem

This subsystem regroups the queries related of some parameters that are measured on-board on the LC-XO-PLUS GPSDO. The list of the commands supported for this subsystem is the following:

MEASure:VOLTage?

MEASure:CURRent?

MEASure?

© 2014 Jackson Labs Technologies, Inc.

4.7.1 MEASure:VOLTage?

This command is not supported in LC-XO-PLUS GPSDO, and will return undetermined values.

4.7.2 MEASure:CURRent?

This command is not supported in LC-XO-PLUS GPSDO, and will return undetermined values.

4.7.3 MEASure?

This command is not supported in LC-XO-PLUS GPSDO, and will return undetermined values.

4.8 SYSTEM Subsystem

This subsystem regroups the commands related to the general configuration of the LC-XO-PLUS GPSDO. The list of the commands supported for this subsystem follows:

SYSTem:COMMunicate:SERial:ECHO <ON | OFF>

SYSTem:COMMunicate:SERial:PROmpt <ON | OFF>

SYSTem:COMMunicate:SERial:BAUD <9600 | 19200 | 38400 | 57600 | 115200>

SYSTem:STATus?

SYSTem:FACToryReset ONCE

4.8.1 SYSTem:COMMunicate

4.8.1.1 SYSTem:COMMunicate:SERial:ECHO

This command enables/disables echo on RS-232. This command has the following format:

SYSTem:COMMunicate:SERial:ECHO <ON | OFF>

4.8.1.2 SYSTem:COMMunicate:SERial:PROmpt

This command enables/disables the prompt “scpi>” on the SCPI command lines. The prompt must be enabled when used with the software GPSCon. This command has the following format:

SYSTem:COMMunicate: SERial:PROmpt <ON | OFF>

4.8.1.3 SYSTem:COMMunicate:SERial:BAUD

This command sets the RS-232 serial speed. The serial configuration is always 8 bit, 1 stop bit, no parity, no HW flow control. Upon Factory reset, the speed is set at 115200 bauds. This command has the following format:

SYSTem:COMMunicate:SERial:BAUD <9600 | 19200 | 38400 | 57600 | 115200>

© 2014 Jackson Labs Technologies, Inc.

4.8.2 SYSTem:STATus?

This query returns a full page of GPS status in ASCII format. The output is compatible with GPSCon.

4.8.3 SYSTem:FACToryReset ONCE

This command applies the Factory Reset setting to the EEPROM. All aging, tempco, and user parameters are overwritten with factory default values.

4.9 SERVO Subsystem

This subsystem regroups all the commands related to the adjustment of the servo loop:

SERVo:COARSeDac <int> [0,225]

SERVo:DACGain <int> [0.1,10000]

SERVo: EFCScale <float>[0.0 , 500.0]

SERVo:EFCDamping <float>[0.0 , 4000.0]

SERVo:SLOPe <NEG | POS >

SERVo:TEMPCOmpensation <float> [-4000.0, 4000.0]

SERVo:AGINGcompensation <float> [-10.0, 10.0]

SERVo:PHASECOrrection <float> [-100.0, 100.0]

SERVo:1PPSoffset <int> ns

SERVo:QUIet <ON | OFF>

SERVo:TRACe <int > [0,255]

SERVo?

4.9.1 SERVo:COARSeDac

This command sets the coarse DAC that controls the EFC. The LC-XO-PLUS GPSDO control loop automatically adjusts this setting. The user should not have to change this value.

This command has the following format:

SERVo:COARSeDac <int> [0,225]

4.9.2 SERVo:DACGain

This command is used for factory setup.

4.9.3 SERVo: EFCScale

Controls the Proportional part of the PID loop. Typical values are 0.7 (double oven OCXO) to 6.0 (simple single oven OCXO). Larger values increase the loop control at the expense of increased noise while locked. Setting this value too high can cause loop instabilities.

© 2014 Jackson Labs Technologies, Inc.

This command has the following format:

SERVo: EFCScale <float>[0.0 , 500.0]

4.9.4 SERVo:EFCDamping

Sets the Low Pass filter effectiveness of the DAC. Values from 2.0 to 50 are typically used. Larger values result in less noise at the expense of phase delay.This command has the following format:

SERVo:EFCDamping <float>[0.0 , 4000.0]

4.9.5 SERVo:SLOPe

The parameter determines the sign of the slope between the EFC and the frequency variation of the OCXO. This parameter should be set to match your OCXO's EFC frequency slope. This command has the following format:

SERVo:SLOPe <NEG | POS >

4.9.6 SERVo:TEMPCOmpensation

This command is not supported in the LC-XO-PLUS GPSDO, and is set to 0.0 by default.

SERVo:TEMPCOmpensation <float> [-4000.0, 4000.0]

4.9.7 SERVo:AGINGcompensation

This parameter is a coefficient that represents the drift of the EFC needed to compensate the natural drift in frequency of the OCXO due to aging. This coefficient is automatically computed and adjusted over time by the Jackson Labs Technologies, Inc. firmware. This command has the following format:

SERVo:AGINGcompensation <float> [-10.0, 10.0]

4.9.8 SERVo:PHASECOrrection

This parameter sets the Integral part of the PID loop. Loop instability will result if the parameter is set too high. Typical values are 10.0 to 30.0. This command has the following format:

SERVo:PHASECOrrection <float> [-100.0, 100.0]

4.9.9 SERVo:1PPSoffset

This command sets the LC-XO-PLUS GPSDO 1PPS signal's offset to UTC in 16.7ns steps.

Using the SERV:1PPS command results in immediate phase change of the 1PPS output signal.

This command has the following format:

SERVo:1PPSoffset <int> ns

© 2014 Jackson Labs Technologies, Inc.

4.9.10 SERVo:TRACe

This command sets the period in seconds for the debug trace. Debug trace data can be used with Ulrich Bangert's "Plotter" utility to show UTC tracking versus time etc.

This command has the following format:

SERVo:TRACe <int > [0,255]

An example output is described here:

08-07-31 373815 60685 -32.08 -2.22E-11 14 10 6 0x54

[date][1PPS Count][Fine DAC][UTC offset ns][Frequency Error Estimate][Sats Visible][Sats Tracked][Lock State][Health Status]

Please see the **SYNChronization?** command for detailed information on how to decode the health status indicator values.

Note: health status information is available with firmware versions 0.913 and later.

The Lock State variable indicates one of the following states:

Value	State
0	OCXO warmup
1	Holdover
2	Locking (OCXO training)
4	[Value not defined]
5	Holdover, but still phase locked (stays in this state for about 100s after GPS lock is lost)
6	Locked, and GPS active

4.9.11 SERVo?

This command returns the result of the following queries:

SERVo:COARSeDac?

SERVo:DACGain?

SERVo: EFCScale?

SERVo:EFCDamping?

SERVo:SLOPe?

SERVo:TEMPCOmpensation?

© 2014 Jackson Labs Technologies, Inc.

SERVo:AGINGcompensation?

SERVo:PHASECOrrection?

SERVo:1PPSoffset?

SERVo:TRACe?

© 2014 Jackson Labs Technologies, Inc.

© 2014 Jackson Labs Technologies, Inc.

5 Certification and Warranty

5.1 Certification

Jackson Labs Technologies, Inc. certifies that this product met its published specifications at time of shipment.

5.1.1 Warranty

This Jackson Labs Technologies, Inc. hardware product is warranted against defects in material and workmanship for a period of 1 (one) year from date of delivery. During the warranty period Jackson Labs Technologies, Inc. will, at its discretion, either repair or replace products that prove to be defective. Jackson Labs Technologies, Inc. does not warrant that the operation for the software, firmware, or hardware shall be uninterrupted or error free even if the product is operated within its specifications.

For warranty service, this product must be returned to Jackson Labs Technologies, Inc. or a service facility designated by Jackson Labs Technologies, Inc. Customer shall prepay shipping charges (and shall pay all duties and taxes) for products returned to Jackson Labs Technologies, Inc. for warranty service. Except for products returned to Customer from another country, Jackson Labs Technologies, Inc. shall pay for return of products to Customer. If Jackson Labs Technologies, Inc. is unable, within a reasonable time, to repair or replace any product to condition as warranted, the Customer shall be entitled to a refund of the purchase price upon return of the product to Jackson Labs Technologies, Inc.

5.1.2 Limitation of Warranty

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by the Customer, Customer-supplied software or interfacing, unauthorized modification or misuse, opening of the instruments enclosure or removal of the instruments panels, operation outside of the environmental or electrical specifications for the product, or improper site preparation and maintenance. **JACKSON LABS TECHNOLOGIES, INC. SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR**

© 2014 Jackson Labs Technologies, Inc.

PURPOSE. No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document. Jackson Labs Technologies, Inc. products are not intended for use in medical, life saving, or life sustaining applications.

5.1.3 Exclusive Remedies

THE REMEDIES PROVIDED HEREIN ARE THE CUSTOMER'S SOLE AND EXCLUSIVE REMEDIES. JACKSON LABS TECHNOLOGIES, INC. SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

© 2014 Jackson Labs Technologies, Inc.